INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
11–287/AWS/2012/14–1–75–80
http://www.fspublishers.org

Full Length Article

Genesis and Classification of some Mollisols Developed under Forest Vegetation in Bursa, Turkey

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ABSTRACT

In this research morphological characteristics and physicochemical properties of selected four soil profiles, developed on different parent material under forest cover, were studied. Soil formation in all studied profiles is characterized by downward movement of clay and organic matter, forming *cambic* and/or *mollic* horizons with high base status. Addition and accumulation of organic materials and leaching bases are the other soil forming factors. The profiles have dark color with moderate-strong blocky structure, high cation exchange capacity and clay content with high base saturation. The main limitation factors regarding soil productivity for the studied soils are soil shallowness, summer drought, and high contents of clay. Problem related to salinity and alkalinity was not found in the studied soils. On the basis of morphological and physicochemical analysis, soil profiles were classified as *Typic* and *Vertic Haploxeroll* sub groups according to the Soil Taxonomy and as in *Calcaric Phaeozem* soil units according to the FAO/UNESCO Soil Map of the World Legend classification systems. The results of this study can be used for to compare with the other studies on Mollisols in wherever they are recognized. This study also provides useful soil data for decision makers and planners in order to produce the new management plans of the study area.

Key Words: Mollisols; Soil morphology; Soil classification; Soil taxonomy

INTRODUCTION

Soil is a natural body and develops from the parent material through time under the effect of climate, vegetation, and topography. These factors of soil formation are interdependent. Changing one of these soil forming factors causes to change the others and this presents differences in soil patterns (Fanning & Fanning, 1989; Malo, 2006). As a result of this the soil will show variation at different times within the development of a landscape. It is generally agreed that it is possible to group soils together into classes, within which many properties of the soil may be expected to be similar. Soil classification seeks to group these soils into classes or taxonomic units and the related practice of soil survey seeks to map the soils into spatially homogeneous groups so that they may be portrayed on maps (Nortcliff, 2005). Today, various soil classification systems are being used in the world. Among these most widely used soil classification systems are the Soil Taxonomy (Soil Survey Staff, 1999; 2006) and the FAO/UNESCO Soil Map of the World Legend (FAO/UNESCO, 1974; 1990), which are also forming the subject of this study.

As it is described in Soil Taxonomy (Soil Survey Staff, 1999), *Mollisols* commonly are the very dark colored, base-rich (*mollic* epipedon), and mineral soils of the steppes. Nearly all of these soils have a *mollic* epipedon. Many also have an *argillic*, *natric*, or *calcic* horizon and a few have an *albic* horizon. Some also have a *duripan* or a *petrocalcic* horizon. *Mollisols* are extensive in sub-humid to semiarid areas at mid latitudes, but they also occur at high latitudes and high altitudes and in tropics. Many of these soils developed under grass at some time, although many apparently were forested at an earlier time. Some of the soils that are in the mountains or that were derived from highly calcareous parent material apparently formed under forest vegetation. *Mollisols* are naturally fertile soils, because they are rich in humus that stores mineral nutrients and water. They have a strong structured surface layer that has high organic carbon content and has a base saturation of more than 50% throughout. The soil reaction value of these soils ranges from medium acid at high elevations to moderately alkaline at lower elevations on fans and terraces. They primarily occur on lake terraces, alluvial fans, foothills, mountains, and high plateaus and valley bottoms (Soil Survey Staff, 1999). Globally, *Mollisols* are ubiquitous throughout the grasslands of sub-humid to semiarid climates, including Eastern Europe; Asia, from Turkey and Ukraine eastward across Russia; the pampas region of South America; and parts of Mexico and Central America (Thompson & Bell, 2001).

Although, *Mollisols* are among some of the most

To cite this paper: Ozsoy, G. and E. Aksoy, 2012. Genesis and classification of some mollisols developed under forest vegetation in Bursa, Turkey. *Int. J. Agric. Biol.*, 14: 75–80

productive agricultural soils (Soil Survey Staff, 1999), they are generally under natural vegetation in the study area. Generally *Entisols* and *Vertisols* are being widely used for crop production in the study area. However, it seems that the *Mollisols* are forgotten. It is understood that the properties of these soils are unknown for their accurate and sustainable management. Therefore, a research attempt to clarify the genesis of these Mollisols is needed for this area. The literature is also limited of studies subjected to Mollisols developed under forest cover. On the other hand, today, there is no detailed soil taxonomic data for Turkish soils. In Turkey, the only soil data (soil map, scale 1:100,000) was produced by the General Directorate of Rural Services of Turkey (KHGM) in 1970s and presented based on soil great groups level. Unfortunately these maps couldn't be updated well according to the new soil taxonomic classification, yet. Thus, there is a sense of urgency to update the soil data in Turkey to be used in land use planning or management studies. The other case in the conduct of this study is the need of new and correct information about soils of the area for decision makers while designing the new management plans of the Bursa metropolitan.

This study was conducted to determine and interpret the morphological, physical and chemical properties of the studied soils, to introduce *Mollisols* developed under forest cover in the Mediterranean climate of northwest Turkey, and to recommend some solutions for the problems and management of these soils.

MATERIALS AND METHODS

The soil profiles presented in this research were described and sampled in the northwest side of the Bursa province, the fourth biggest city of Turkey. The selected profiles were situated between 40°13' 44" - 40°16' 00" N latitudes and 28°50' 40" - 28°52' 55" E longitudes, at elevations ranging between 80 and 155 m. The location information of each profile was given in Table I. All the studied soils were developed under natural forest cover (reconstructed after the great fire incident in 1980s) but occur on various parent materials (sandstone, claystone, marn, conglomerate) having high amount of $CaCO_3$ content. This part of Turkey is characterized by a Mediterranean-continental climate consisting of hot and dry summers and mild and rainy winters. The annual precipitation is around 700 mm most of which occurs from October to May, and the mean annual temperature is about 14.5° (DMI, 2006; Ozsoy & Aksoy, 2007).

Morphological properties of the soil profiles in the field were accomplished according to the Soil Survey Division Staff (1993) and Schoeneberger *et al.* (2002). Representative bulk samples of the recognized horizons in each profile were taken for laboratory analysis. The bulk soil samples were air dried, crushed with a mortar and pestle, and sieved to remove coarse (>2 mm) fragments for physico-chemical analyses (Schoeneberger *et al.,* 2002). Bulk density, field capacity, wilting point and available water was determined according to Tan (2005). The particle size fraction was determined by the hydrometer method (Tan, 2005). Soil pH and electrical conductivity (EC) was measured in a 1:2.5 soil-water suspension after an hour of intermittent shaking and overnight stand. $CaCO_3$ content was determined according to Richards (1954). Organic matter content was determined according to the modified Walkley-Black Method as described by Nelson and Sommers (1982). Exchangeable bases (Na, K, Ca & Mg) were extracted with 1 N neutral ammonium acetate solution at pH 7.0 (Pratt, 1965). The concentrations of exchangeable bases in the extracts were measured by Eppendorf Elex 6361 model Flame photometer. Cation exchange capacity (CEC) was determined by ammonium acetate method (Tan, 2005).

On the basis of morphological and physicochemical properties, the soil profiles were classified up to sub group level according to the Soil Taxonomy (Soil Survey Staff, 1999; 2006) and the FAO/UNESCO Soil Map of the World Legend (FAO/UNESCO, 1974; 1990).

RESULTS AND DISCUSSION

Morphological properties of the studied soil profiles: The morphological properties of the soil profiles were given in Table I. The soils have parent material mostly cemented with neogene lime-clay deposits, moderate slope, AC and ABC horizon and shallow depth. They have generally wavy topography and resemble a bowl, lying south-north direction. Most of the lands around in the study site have a slope range of 3% to 6%, fine texture (clay), and well drained profiles. From surface to deep, there were gravels in different origin, shape and amount.

The color of the profiles was read from 10 YR (Profile 1-2) and 7.5 YR (Profile 3-4) in the Munsell color chart when dry and moist. The color of Profile 1 was grayish yellow brown (10 YR 4/2) when dry. When moist, the color changes to brownish black (10 YR 3/2) in the surface horizon and dull yellowish brown (10 YR 4/3) in the subsurface horizon. In the C horizon of Profile 1 the color was light gray (10 YR 8/1) when dry and dull yellow orange (10 YR 7/2) when moist. In Profile 2 the color was brownish black (10 YR 3/2) for the surface and subsurface horizons but it was dark brown (10 YR 3/3) in the BC horizon and dull yellow orange (10 YR 7/2) in the C horizon when moist. Profile 3 possessed dark brown (7.5 YR 3/3) color through the solum when moist but it was brownish black (7.5 YR 3/2) in the surface horizon when dry and dull orange (7.5 YR 7/3) in the C horizon when moist. For the surface horizon of Profile 4 the color was dark brown (7.5 YR 3/3) when dry and wet while it was read from dark brown (7.5 YR 3/4), brown (7.5 YR 4/3), and grayish brown (7.5 YR 5/2) when wet in the A_2, AC, and C horizons, respectively.

Table I: Morphological properties of the studied soils

Horizon	Depth (cm)	Boundary[1]	Color		Structure[2]	Texture	Consistency[3]			Roots[4]	Rocks[5]	Effervescence[6]	Pores[7]
			Dry	Moist			Dry	Moist	Wet				
Profile 1: location: 40^0 14' 25" N - 28^0 51' 46" E, elevation 155 m., hill-ridge, situated on southeast aspect, slope 6%, wavy topography, land cover: forest (mix-pine), parent material: calcareous sandstone.													
A_1	0-23	g,w	10 YR 4/2	10 YR 3/2	mo,md,ab	C	h	vfr	vs,p	c,md	fw,gr,a	mc	c,fn,tb
AC	23-37	g,w	10 YR 4/2	10 YR 4/3	mo,fn,ab	C	h	vfr	s,sp	c,md	md,gr,a,r	hc	c,fn,tb
C	37+	--	10 YR 8/1	10 YR 7/2	wk,fn,ab	CL	--	vfr	s,sp	--	vm,gr,sw	vhc	--
Profile 2: location: 40^0 14' 50" N - 28^0 52' 50" E, elevation 110 m., hill-ridge, situated on northwest aspect, slope 4 %, wavy topography, land cover: forest (*Pinus brutia*), parent material: calcareous claystone, intense biological activity and limestone, marn pieces in 0.2-6cm diameter through the profile.													
A_1	0-22	g,w	10 YR 3/2	10 YR 3/2	st,md,ab	C	vh	fr	s,p	m,md,co	md,gr,r	mc	m,fn,tb
Bw	22-44	g,w	--	10 YR 3/2	st,md,ab	C	vh	fr	s,p	c,fn,md	md,gr,r	hc	m,fn,tb
BC	44-67	c,w	--	10 YR 3/3	st,co,ab	C	--	vfr	s,p	fw,co	m,gr,r,w	hc	c,fn,tb
C	67+	--	--	10 YR 7/2	st,co,ab	C	--	fi	s,vp	--	m,gr,r,w	vhc	--
Profile 3: location: 40^0 13' 45" N - 28^0 52' 42" E, elevation 105 m., gently slope land, situated on west aspect, slope 3%, flat topography, land use: forest *(Oak, Quercus robur)*, parent material: calcareous conglomerates (colluvium), different origin of gravel pieces (quartz, limestone) in 0.2-6cm diameter through the profile, good biological activity.													
A_1	0-13	g,s	7.5 YR 3/2	7.5 YR 3/3	st,md,sb	C	h	fr	ss,p	fw,vfn	m,gr,r	nc	c,fn,tb
Bw	13-35	c,s	--	7.5 YR 3/3	st,md,ab	C	--	fr	ss,p	c,md,co	m,gr,r	nc	c,fn,tb
BC	35-49	g,w	--	7.5 YR 3/3	wk,fn,sb	C	--	vfr	ss,p	m,md,co	vm,gr,w	hc	c,vf,tb
C	49+	--	--	7.5 YR 7/3	wk,fn,sb	CL	--	vfr	ss,sp	--	vm,gr,sw	vhc	--
Profile 4: location: 40^0 15' 52" N - 28^0 50' 50" E, elevation 80 m., moderately slope land, situated on southwest aspect, slope 6%, wavy topography, land use: forest *(Oak, Quercus robur)*, parent material: marn, different origin of gravel pieces (quartz, limestone) in 0.2-6cm diameter through the profile, cracks (in 0.5-1cm diameter) within 23cm depth (ended by AC horizon), slickensides in A_2 horizon, good biological activity.													
A_1	0-16	c,s	7.5 YR 3/3	7.5 YR 3/3	st,md,ab	C	vh	fr	s,p	m,md,co	m,gr,a	sc	m,fn,tb
A_2	16-23	c,s	--	7.5 YR 3/4	st,md,ab	C	--	fi	s,p	m,md,co	m,gr,a	sc	m,fn,tb
AC	23-54	g,w	--	7.5 YR 4/3	wk,fn,ab	C	--	vfr	s,sp	c,md,co	vm,gr,r,w	hc	c,fn,tb
C	54+	--	--	7.5 YR 5/2	ma	C	--	vfr	vs,p	--	vm,gr,sw	vhc	--

1. c:clear; g:gradual; s:smooth; w:wavy.
2. wk:weak; mo:moderate; st:strong; fn:fine; md:medium; co:coarse; ab:angular blocky; sb:subangular blocky; ma:massive.
3. h:hard; vh:very hard; vfr:very friable; fr:friable; fi:firm; ss:slightly sticky; s:sticky; vs:very sticky; sp:slightly plastic; p:plastic; vp:very plastic.
4. fw:few; c:common; m:many; vfn:very fine; fn:fine; md:medium; co:coarse.
5. fw:few (2-5%); md:medium (5-15%); m:many (15-40%); vm:verymuch (40-80%); gr:gravel (0.2-6cm); a:angular; r:round; w:weathared; sw:highly weathared.
6. nc:noncalcareous; sc:slightly calcareous; mc:medium calcareous; hc:high calcareous; vhc:very high calcareous.
7. c:common; m:many; vf:very fine (1-2mm); fn:fine (2-5mm); tb:tubular.

Table II: Some important physical properties of the studied soils

Horizon	Depth (cm)	Particle size distribution (%)			Texture class	Bulk density ($Mg\ m^{-3}$)	Field capacity	Wilting point	Available water
		Sand	Silt	Clay			(m^3 water m^{-3} soil)		
Profile 1									
A_1	0-23	37.71	18.24	44.05	C	1.28	0.36	0.24	0.12
AC	23-37	38.44	19.65	41.91	C	1.30	0.35	0.23	0.12
C	37+	38.32	26.37	35.31	CL	1.32	0.32	0.19	0.13
Profile 2									
A_1	0-22	33.22	17.86	48.92	C	1.26	0.40	0.28	0.12
Bw	22-44	30.01	16.80	53.19	C	1.25	0.42	0.29	0.12
BC	44-67	29.18	19.99	50.83	C	1.25	0.41	0.29	0.13
C	67+	19.57	25.04	55.39	C	1.22	0.46	0.33	0.13
Profile 3									
A_1	0-13	32.48	17.66	49.86	C	1.26	0.39	0.27	0.12
Bw	13-35	32.19	16.22	51.59	C	1.25	0.41	0.28	0.12
BC	35-49	32.87	21.49	45.64	C	1.27	0.38	0.25	0.13
C	49+	44.74	22.29	32.97	CL	1.35	0.30	0.18	0.12
Profile 4									
A_1	0-16	41.18	14.23	44.59	C	1.29	0.35	0.24	0.11
A_2	16-23	34.38	12.30	53.32	C	1.25	0.41	0.30	0.11
AC	23-54	25.54	20.27	54.19	C	1.23	0.44	0.31	0.13
C	54+	22.07	19.61	58.32	C	1.22	0.46	0.33	0.13

The common structures of the studied profiles were angular blocky in moderate to strong resistance but it was generally sub-angular blocky in Profile 3. The strong structure in these soils could be attributed to the high clay content (Table II). According to Fanning and Fanning (1989) the high clay content in soils brings out excessive

Table III: Some important chemical properties of the studied soils

Horizon	Depth (cm)	pH (1:2.5) H_2O	EC (dS m^{-1})	CEC* (cmol kg^{-1})	Exchangeable cation (cmol kg^{-1})			$CaCO_3$ (%)	Organic Matter (%)
					Na^+	K^+	$Ca^{2+}+Mg^{2+}$		
					Profile 1				
A_1	0-23	7.35	0.45	43.47	0.20	0.84	42.43	6.08	2.54
AC	23-37	7.34	0.45	39.60	0.20	0.62	38.78	17.28	1.56
C	37+	7.54	0.22	25.42	0.17	0.29	24.96	42.21	0.74
					Profile 2				
A_1	0-22	7.40	0.59	48.08	0.20	0.77	47.11	3.75	2.09
Bw	22-44	7.53	0.48	46.41	0.21	0.58	45.62	7.90	0.97
BC	44-67	7.57	0.41	36.69	0.21	0.47	36.01	19.50	0.62
C	67+	7.80	0.20	28.32	0.16	0.17	27.99	44.49	0.19
					Profile 3				
A_1	0-13	6.86	0.50	46.94	0.18	1.14	45.62	0.35	2.45
Bw	13-35	6.70	0.45	50.61	0.18	0.93	49.50	0.15	1.15
BC	35-49	7.20	0.39	43.27	0.21	0.51	42.55	20.93	0.83
C	49+	7.45	0.17	28.09	0.15	0.14	27.80	46.28	0.38
					Profile 4				
A_1	0-16	7.13	0.55	41.08	0.20	0.82	40.06	1.63	2.76
A_2	16-23	7.02	0.64	51.12	0.22	0.72	50.18	0.84	0.82
AC	23-54	7.43	0.41	38.95	0.20	0.44	38.31	51.15	0.88
C	54+	7.66	0.22	24.04	0.17	0.18	23.69	66.54	0.56

*Cation exchange capacity

Table IV: Classification of the soil profiles according to the Soil Taxonomy and the FAO/UNESCO classification systems

Soils	Order	Suborder	Great group	Subgroup	FAO/Unesco
Profile 1	Mollisol	Xeroll	Haploxeroll	Typic Haploxeroll	Calcaric Phaeozem
Profile 2					
Profile 3					
Profile 4				Vertic Haploxeroll	

shrink-swell actions during drying and wetting cycles. This might be the one reason for the observed cracks in the studied soils (especially permanent in profile 4). Besides, all the profiles were in clay texture when it was examined by finger test during the field works, which might be the other reason for the crack formation. The consistency was hard and very hard when the soils were at dry condition. They were friable and very friable when moist, and changed from slightly sticky to plastic when wet. The boundaries of all the horizons in the studied soil profiles were generally wavy, gradual and clear. There was a good biological activity through the solum of the profiles with common, fine and tubular pores. There was evidence of roots (medium & coarse) and rocks (gravel) in all the profiles with plenty iron concretions and calcium nodules. Unlike others, in Profile 2 and 3 a Bw horizon was observed, which is probably formed by accumulation of clay leaching from surface and influenced the texture, color and structure of the horizon (Table I).

The physical and chemical properties of the studied soil profiles: Some important physical and chemical properties of soil profiles were summarized in Table II and Table III, respectively. In the studied soils total clay content was high (32.97-58.32%) throughout the depth of all profiles. It was significantly decreasing with depth in Profile 1 and 3, which were developed on sandstones. The bulk density was decreasing with depth in Profile 2 and 4 but increasing in Profile 1 and 3 due to their parent material type. Dark color (mainly black) in soils has been attributed to coloration due to organic matter (Harden, 1982). The organic matter values were varied from 2.09% to 2.76% in the surface horizons but decreased with depth. In *Mollisols* it is expected to have moderate to high organic matter content (Soil Survey Staff, 1999). Due to organic matter and clay contents, CEC was found high and the values varied from 24.04 to 51.12 cmol kg^{-1}. Exchangeable Ca^{+2} and Mg^{+2} are dominant cations in all the soils and varied from 23.69 to 50.18 cmol kg^{-1}. The base saturation of all the studied soils was very high (100%). Vegetation plays an important role in maintaining the base-cation (Ca, Mg, K & Na) content of *Mollisols* (Laudelot & Robert, 1994; Quideau *et al.*, 1996). The pH values ranged from 6.7 to 7.8. The $CaCO_3$ content of the soils were less in surface horizons but increased with the depth and reached the highest values at the C horizons. The high values in $CaCO_3$ contents were expected to be found in the studied profiles. Because all the parent materials of the studied soils are compacted or cemented with calcareous deposits or they have the mixture of it. Low $CaCO_3$ values at the upper horizons were resulted from leaching. The lowest $CaCO_3$ values were found in the surface and subsurface horizons of Profile 3. This might be the reason of scarcity of runoff due to smooth slope and enables infiltration and leaching. Problem related to salinity and alkalinity was not found in the studied soils. Effective root depth was measured as 23, 44, 35 and 23 cm. for Profile 1, 2, 3 and 4, respectively. Both the soils have a considerable amount of biological activity (roots, insects, bugs, etc.) and litter decomposition.

Soil classification: Soil profiles investigated in the area had only *mollic* epipedon as a diagnostic surface horizon at the surface. The *Mollic* epipedon was designed to group soils strongly influenced by calcification. Most *Mollisols* and a few soils of other orders have *mollic* epipedons (Soil Survey Staff, 1999). In the subsurface of the Profile 2 and 3 a *cambic* horizon was defined as a result of organic matter addition and transformation, and translocation of $CaCO_3$. No *calcic* horizon has formed in these soils, mainly due to the lack of wetting and drying cycles as a result of the permanent saturation. According to the meteorological data, the research area has "*mesic*" soil temperature and "*xeric*" soil moisture regime (Soil Survey Staff, 1999). Based on morphological, physicochemical analysis and soil moisture regime, soil profiles were classified according to the Soil Taxonomy (Soil Survey Staff, 1999; 2006) and the FAO/UNESCO Soil Map of the World Legend (FAO/UNESCO, 1974; 1990) classification systems as a *Typic Haploxeroll* (Profile 1,2,3) and *Vertic Haploxeroll* (Profile 4) sub groups and as in *Calcaric Phaeozem* soil units, respectively (Table IV).

Recommendations for management and planning: *Mollisols*, formed under grasses or some forests, tend to be the most fertile soils. They have higher humus contents and thus higher concentrations of plant nutrients than some other orders have (Gardiner & Miller, 2008). *Mollisols* therefore, are favored by a native vegetation of grasses. Certain forest soils occurring in semiarid climates or on high calcareous parent material may also favor *Mollisols* if the soil biota is able to incorporate the organic matter deep enough. Often the cellulose breakdown from leaves occurs at a rapid pace and the carbonic acid leaches the calcium. Grasses, however, produce much of their growth underground and contain abundant lignin and protein. These substances lead to high preservation of produced materials as soil organic matter (Fanning & Fanning, 1989).

All these facilities make these soils productive for agriculture. They have high natural fertility and base status. It can be recommended to convert these lands into arable land-uses in order to utilize its high nutrient reserves (Tekwa *et al.*, 2010). But, the studied soils are found shallow and prone to erosion because of their slope gradient. Therefore, if these lands were forced to use for agriculture, a soil degradation problem may occur. In addition, with the *Xerolls*, there is a shortage of moisture for many crops. For this reason *Xerolls* are suitable for wheat and rangeland. Crops must be grown to take advantage in the spring of the moisture accumulated over the winter months, especially with the *Xerolls*, which receive very little rainfall in the summer (Fanning & Fanning, 1989). If these lands scheduled to open for agriculture, an irrigation scheme can be constructed in the area to eliminate this negative effect. Moreover, management practices like minimum or reduce tillage, mulching, intercropping and terracing (for some areas) could be adapted for a sustainable agriculture.

Consequently, the main limitation factors regarding soil productivity for the studied soils are soil shallowness, summer drought, and high contents of clay. Problem related to salinity and alkalinity was not found in the studied soils. The clay contents of the studied soils were found high. In agriculture, inappropriate soil tilling and using unsuitable instruments, especially in clay rich soils, firstly cannot manage healthy plant growth and cause soil degradation in long time periods (Ozsoy & Aksoy, 2007). Cultivation practices change soil water content, aeration and the degree of mixing of crop residues within the soil matrix, thereby affecting soil organisms, which have important functions in soils such as structure improvement, nutrient cycling and organic matter decomposition (Kladivko, 2001). However, soil cultivation affects soil quality in various ways. With high clay content, cultivation may lead to the formation of a hard pan below the plough layer that restricts root penetration and downward movement of water (Singh & Singh, 1996). On the other hand, it is declared in some researches that soil tillage with mulching or intercropping practices has involved an increase on plant growth and yield (Khurshid *et al.*, 2006; Ahadiyat & Ranamukhaarachchi, 2008; Borghei *et al.*, 2008).

It is also understood that these *Mollisols*, although under forest cover, have faced an important problem in terms of soil erosion. Because of the Mediterranean climate properties of the region, the parent material of the soils and slope factor compose suitable conditions for water erosion. Hence, if these areas are planning to be used in agriculture, we strongly recommend that close attention should be paid for the soil erosion, soil cultivation, irrigation system and time regarding the soil type.

CONCLUSION

The present study provides information on characteristics, formation and determination of *Mollisols* in a Mediterranean environment. The studied *Mollisols* were developed under forest vegetation and derived from different calcareous parent material (sandstone, claystone, conglomerate, marn). The studied soils are shallow, non-saline and alkaline, clay in texture throughout their profiles. They have high CEC and base saturation due to their texture and organic matter contents. Soil formation in all studied profiles is characterized by downward movement of clay and organic matter, forming *cambic* and/or *mollic* horizons. The addition and accumulation of organic materials and leaching bases are the other soil forming factors. In addition, this study provides useful soil data for decision makers and planners in order to produce the new management plans of the area. Also some recommendations were discussed. The results of this study can also be used for to compare with the other studies on *Mollisols* in wherever they are recognized.

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(Received 26 April 2011; Accepted 03 October 2011)